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Eden, Ece; Frencken, Jo; Gao, Sherry; Horst, Jeremy A.; Innes, Nicola

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Managing Dental Caries Against the Backdrop of Covid-19; Approaches to Reduce Aerosol Generation

Eden E, Frencken J, Gao S, Horst J, Innes N

Abstract

The COVID-19 pandemic resulted in severe limitation and closure of dental practices in many countries. Outside of the acute phase of the disease, dentistry can begin to be practised again. However, there is emerging evidence that SARS-CoV-2 can be transmitted via airborne routes carrying implications for dental procedures that produce aerosol. At the time of writing, additional precautions are required when a procedure considered to be aerosol generating is undertaken.

The paper aims to present evidence-based treatments that remove or reduce the generation of aerosols during the management of carious lesions. It will map aerosol generating procedures, where possible to alternative non-aerosol generating or low-aerosol generating ones. This risk reduction approach overcomes the less favourable outcomes associated with temporary solutions or extraction-only approaches. Even if this risk reduction approach for aerosol generation becomes unnecessary in the future, these procedures are suitable as part of general dental care post-COVID-19.

In brief;

- Uncertainty and the emerging evidence that SARS-CoV-2 may be transmitted via airborne routes has implications for practising dental procedures that generate aerosols.

- There are evidence-based treatments including use of high viscosity glass ionomer sealants, Atraumatic Restorative Treatment, silver diamine fluoride, the Hall Technique and Resin Infiltration that remove or reduce aerosol generation during the management of carious lesions.

- This risk reduction approach for aerosol generation may guide practitioners to overcome the less favourable outcomes associated with temporary solutions or extraction-only approaches in caries management.

Background

The new coronavirus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has precipitated the COVID-19 pandemic. The World Health Organization (WHO)[1] has recommended a society-wide quarantine approach, social distancing and handwashing followed by contact tracing. Alongside this, most countries have suspended elective and non-urgent dental care,[2,3] closing many practices with only emergency treatment provision.[4,5,6] This acute phase of the pandemic is subsiding, although there is a possibility of further acute phases. There is increasing dental need across populations and dental practices are suffering financially, so practices are opening and commencing care. However, the WHO has taken a risk assessment approach and recommended that situations where aerosol generating procedures (AGPs) are carried out should be reduced to a minimum with additional precautions in place.

It is still controversial but there is growing concern over possible airborne transmission of SARS-CoV-2.[4,5,6,7] Although there has been much written about possible spread of COVID-19 through aerosols generated in the dental surgery, reviews of the evidence show there is little directly relating to respiratory viruses, despite over 70 years of research into bio-aerosols in dental settings.[8,9,10,11] Studies of microbial content of aerosols and splatter generated during dental procedures have mostly involved aerobic bacteria.[9,10,11,12,13,14,15] Viral studies are sparse, focusing on blood borne HIV and Hepatitis B.[8,16] This limits confidence in the assumptions around transmission of SARS-CoV-2 during dental treatment.

In general, management of dental caries has traditionally involved using instruments that have potential to generate bio-aerosols containing saliva, blood and tooth debris; the high-speed air rotor,[17,18,19,20,21] slow-speed handpiece[22,23,24] and use of the air-water syringe to complete steps for most dental materials.[16,17,25,26]

Until uncertainty around the level of risk associated with SARS-CoV-2 transmission between dental staff and patients is resolved or an acceptable level of risk is agreed, and because many

aspects of dental treatment generate aerosols, a precautionary position is to keep aerosol generation as low as possible.

Aim

The paper presents evidence-based management for dental caries that remove or reduce the generation of aerosols and aids personalised **care** planning based around AGP reduction.

Caries management strategies that reduce aerosol generation

This paper is set against a background of local, national and international standards and recommendations. These include use of patient flow and environment cleaning processes, standard and enhanced PPE use as well as other measures put in place to run a safe practice whilst COVID-19 is still a health threat. Dental professionals are familiar with infection control strategies but after an outbreak of a highly infective, potentially airborne transmitted virus, extra-protective measures have to be adopted. In this time of emerging evidence resulting in constant change, these should continue to be in line with national and local regulations, with vigilance to changes, and by reference to the Centre for Disease Control.

The paper will consider the alignment of traditional aerosol generating caries management procedures with "non-aerosol generating procedures" (non-AGP) and "low-aerosol generating procedures" (low-AGP) (see Figures 1 and 2). Non-AGPs are those that generally do not include steps that generate aerosols such as the use of rotary instruments and air-water syringe or procedures that can be modified to be carried out in a way that does not generate aerosols and compromise the quality of the procedure. Low-AGPs are those that also contain steps that might generate a lower amount of aerosol that with a high speed or ultrasonic scaler, such as the air-water syringe. Non-AGPs still have potential for salivary contamination and low AGPs may need the air-water syringe in some instances. However, there is less aerosol produced if the water is used to wash without combining it with air to give a spray.[16,26] Use of rubber dam with sealing around tooth holes and high-volume evacuation help minimise risk. **Because of the possibility of viral load in the blood of COVID-19 positive patients, it is preferable to avoid pulpal exposures. The non-invasive and minimally-invasive procedures such as selectively removing carious tissues during ART and the Hall Technique**

are discussed below and make pulp exposures less likely. However, if a pulp exposure did look likely during caries removal, an indirect pulp cap should be considered.

The procedures discussed here are based around Minimal Intervention Dentistry approaches, aiming to maintain the dentition for the life-course by handling the disease, dental caries, in a biological manner; treating the cause and not just its symptoms (the carious lesions).[27]

The non-AGP and low- AGPs for managing carious lesions can be grouped into:

1. Control the disease – prevention, early detection and managing the carious lesion (whether confined to enamel or cavitated) through controlling the biofilm by making the lesion cleansable with Non-Restorative Cavity Control (NRCC) or by removing the plaque and using chemicals to stop its progress and promote remineralisation (commonly; Silver Diamine Fluoride (SDF), topical fluoride);
2. Cover and seal the biofilm and carious lesion – involve no caries removal and creates a seal to deprive the carious biofilm of nutrients, oxygen etc. causing the carious lesion to arrest, such as fissure sealing and resin infiltration for non-cavitated lesions and the Hall Technique (HT);
3. Carious tissue removal – **only decomposed dentine and unsupported demineralised enamel should be removed selectively using hand instruments e.g Atraumatic Restorative Treatment (ART) and/or Chemo-Mechanical Caries Removal (CMCR).**

Figure 3 details further sources and some video tutorials of these techniques.

Methods to control carious lesions

Prevention

Primary preventive approaches **(also known as non-invasive strategies for the management of caries)** can reduce the risk of progressive dental tissue loss and avoid the need for treatments using rotary instruments. The main preventive approaches have to be through the

community and home, with behavioral components such as sugar restriction, plaque removal and oral health education. Clinicians hold a pivotal role in supporting oral health behaviours. For remineralisation, fluoride-based agents are accepted as the primary medicament, although there is less supporting evidence, other remineralisation agents such as self-assembling peptide P11-4[28] might be considered.

Preventive sealants cover plaque retentive areas, occlusal fissures and pits, which are most vulnerable to caries.[29,30] However, resin-based sealants involve a washing step to remove the acid-etch thoroughly, generating some aerosol. Nevertheless, this risk can be avoided by using low viscosity or high viscosity (HV) glass ionomer cement (GIC), and excess material can be removed with hand instruments. A Cochrane review found no difference in the preventive effect of resin, low or HVGIC sealants.[30]

Early detection

The purpose of treating dental caries, is primarily to stop its progression within the tooth as well as restoring the lost dental hard tissues when needed. Early detection of carious lesions will reduce the need for aerosol producing restorative care required for advanced lesions. In addition, patients with active dental caries, need to have their disease risks addressed as part of the long-term disease management.[31,32]

Non-restorative Cavity Control for dentinal lesions

What it is and when to use it

NRCC is a method for using 'cleaning' to prevent biofilm maturation and caries progress.

It can be used for dentinal carious lesions in the primary and permanent dentition, root carious lesions and cavitated coronal smooth surface lesions.

How it works and clinical effectiveness

By making the carious surface accessible and having plaque frequently and thoroughly removed, the carious process will arrest.

In primary teeth, the effectiveness of NRCC in medium and large cavities together with ART restorations in small cavities has been tested in comparison to amalgam and ART restorations.[33] Tooth survival after 3.5 years was 89% and not significantly different from either amalgam (91%) or ART restorations (90%) and in a randomised control trial of occluso-proximal cavitated lesions, survival (of pulp and tooth) was 92% at 2.5 years compared to 98%

for teeth treated with the HT.[34] NRCC has a less robust evidence-base than the other treatment options discussed in this paper with most of the reports of success being related to particular situations and carried out by dentists who support this technique. The choice to use NRCC is less dependent on the shape or type of lesion than it is on the attitude of the patient towards prevention and the skill of the dentist in behaviour change.[35]

Non-AGP use

NRCC consists of three concurrent stages:

1) Working with the patient to make plaque control more successful (improving oral hygiene procedure/habits). The patient has to be ready to change behaviours that led to development of the disease in the first place. Success depends on the clinician's ability to change the patient's (or in the case of a child, the parent's) behaviour towards taking responsibility. So "prevention" becomes very much more than simply providing instruction of what to do (KNOWLEDGE) and how to do it (SKILLS) but has to involve an aspect of refocusing the patient to feeling empowered to make a difference to their own oral health (ATTITUDE). Daily removal or disruption of the biofilm by brushing with a fluoridated toothpaste will slow down the carious process and can even halt it.

2) Creating a cavity shape where the carious biofilm/ dentine is accessible to a toothbrush (lesion exposure). In some cases, overhanging enamel has to be removed. To avoid use of rotary instruments, hand instruments can be used to gain access to the lesion (see ART).

3) Treatment with 38% SDF and/or a 5% NaF varnish therapy to reduce carious activity and promote remineralisation.[33] These additional measures can support success of the NRCC approach if the carious lesion is active or there is increased risk that carious lesion activity will recur.

In the primary dentition, the goal is to avoid the lesion causing pain and/or infection until the tooth exfoliates. For the permanent dentition, with grossly broken-down teeth, root carious lesions or coronal smooth surface lesions, the main goal is to avoid the lesions leading to pain and/or infection whilst also avoiding or delaying the need for restoration.

Silver Diamine Fluoride (SDF) for dentinal lesions

What it is and when to use it

SDF is a clear, colourless, liquid that arrests active cavitated carious lesions and remineralises

demineralised enamel and dentine.[36] **Some products have a blue tint, but these are not available in the UK. Although licensed to treat dentine sensitivity in the UK and some other countries, it is more usually used "off-label" to arrest carious lesion. It** turns active carious lesions black so consent to treatment must be obtained and must be handled with care as it will stain skin, mucosa and most surfaces on contact.

SDF is an effective way to treat active lesions for primary and permanent teeth (coronal dentine, and root).[37,38] It can be used opportunistically, whilst the patient is in the dental chair by applying to other high-risk surfaces. SDF is effective in arresting early childhood caries[39] and exposed root surfaces.[40] It is more successful when used in cleansable lesions and accessible areas of the mouth.[41] When caries is more severe or affects multiple teeth, repeated applications of SDF controls the disease (for example applied after two weeks and six weeks then six months as required).[42]

How it works and clinical effectiveness

SDF penetrates infected dentine,[43] making the lesion twice as hard as healthy dentine.[44] It produces a dense superficial layer and filling in microcavities with solid metallic silver.[45] It also acts directly on the plaque biofilm,[46,47] inhibiting bacterial growth.[48,49] Removing carious tissue before SDF application is not necessary as it does not improve caries arrest.[50]

SDF has been shown to have some effect in preventing carious lesions in primary teeth with one review showing that by applying it at least once per year, 61% of new caries lesions might be prevented.[51] SDF is clinically and cost effective and has the advantage of combined use with all other caries management techniques.[51,52]

Non-AGP use

Carious tissue is not removed at all. To minimize droplet and aerosol production, the surface is dried with cotton instead of compressed air, then SDF is applied using a micro-brush. Arresting lesions using SDF can provide a solid foundation for restorations[53,54] and can be combined with ART in primary or permanent teeth or the HT. There are currently no clinical trials of efficacy, so combinations may be thought of as a "belt and braces" approach to synergise the benefits of both treatments.

Methods for sealing the carious lesion

Fissure sealing over non-cavitated carious lesion

What it is and when to use it

Sealant materials can control non-cavitated lesions on occlusal surfaces where there is no significant breach in the surface integrity of the tooth, even if the lesion can be seen clinically (through shadowing), or radiographically, to extend into dentine.[55,56,57,58,59,60] **These are sometimes known as micro-invasive treatments.**

How it works and clinical effectiveness

As well as being highly effective for prevention of dental caries,[30] placing a well-sealed fissure sealant over a carious lesion will arrest it and stop it from progressing.[57,58,59,60]

Whilst shallow or moderately deep lesions are likely to be successfully managed, there is not enough evidence to make recommendations for deeper lesions for long term management. Although they may provide a good seal, they will not add much to the strength of the tooth. Their application is limited to teeth where there is less weakening of the tooth structure (i.e. less extensive lesions) and the tooth structure can support them. In cases where the lesion is extensive, the sealant may not be able to withstand breakdown of the lesion surface if the forces are high.

Although they have lower retention rate than resin sealants, the therapeutic effect of GIC on the tooth seems to balance the bulk material loss. There is good evidence to support a high caries preventive effect from high-viscosity glass ionomer sealants.[30] However, there is little directly comparable evidence, as yet, on their relative performances sealing dentinal carious lesions.

Non-AGP use

Resin fissure sealant application involves use of the air-water syringe, creating an aerosol. Clinicians could consider using GIC or HVGIC ART sealants instead, as these do not require rinsing or desiccation for placement, to prevent further progression of lesions. More long-term treatment may be required later but there may be sufficient success from the sealant to allow it to be managed by re-sealing rather than replacing with a restoration.

Resin Infiltration

What it is and when to use it

Resin infiltration (RI) is a technique that arrests non-cavitated carious lesions.[61,62] It can treat non-cavitated lesions on smooth and approximal surfaces in both dentitions effectively. Lesions have to be limited to enamel and the outer third of dentine.[61,62,63,64,65] It can also camouflage the whitish appearance of hypomineralised enamel on smooth surfaces.[62,64] **Similar to sealants, this is sometimes known as a micro-invasive treatment.**

How it works and clinical effectiveness

A very low viscosity resin infiltrate is introduced into the micro-porosities of carious lesions to fill them, through capillary action and arrest their progress.[65] Systematic reviews show RI to be an effective microinvasive treatment at timespans up to 36 months.[61,65]

Low-AGP use

The diffusion of the resin infiltrate results from surface and sub-surface dehydration conditions created by hydrochloric acid followed by ethanol. The air-water syringe has to be used to rinse and dry which may produce aerosols. Rubber dam, sealing material and high-volume evacuators should be used.[5,66]

Hall Technique

What it is and when to use it

The HT is a method for treating asymptomatic carious primary molar teeth where the lesion has extended into dentine, (cavitated or non-cavitated). The correct size of preformed metal crown is chosen and then pushed over the tooth to seal the carious lesion.[67]

The HT has been used in some secondary care settings for temporary management of partially erupted permanent molars affected by molar incisor hypomineralisation. However, there are currently no clinical trials to support this use. If practitioners are considering using the Hall Technique as a temporary non-AGP measure for permanent molar teeth, there are a few points, besides the lack of supporting evidence that they should consider. Firstly, the crowns should only be placed on teeth that are not yet in occlusion. Secondly, the HT in this case provides only a temporary solution until more definitive restorative treatment and this will necessitate an AGP to remove the crown. Finally, permanent tooth preformed crowns

are less easy to fit than those for primary teeth and almost always need to be trimmed with scissors, crimping and polishing.

How it works and clinical effectiveness

It provides full coronal coverage and the risk of future carious lesion development on another surface of the tooth is avoided.[67]

The HT is technically simple to carry out and is well accepted by children, their parents and dentists.[68,69] It has a strong evidence base showing high long-term success rates in randomised control trials (> 90%) compared to conventional restorations (50% to 80%) and comparable to conventional crowns.[68,69,70] The high rate of success, its durability and cost-effectiveness have meant use of the HT has increased with a recent survey including 709 Paediatric Dentists from six continents where 92% had heard about and 51% were using it.[71]

Non-AGP use

The HT is AGP-free as there is no removal of carious tissue and no tooth preparation. No local anaesthesia is required. The luting cement is GIC. As with all clinical procedures, careful case selection with accurate lesion and pulp status diagnoses (clinically and radiographically) are essential for success. Parents have to be happy with the appearance before placement although children generally like the crown's appearance.

Methods for dentine carious lesion management

Atraumatic Restorative Treatment

What it is and when to use it

ART involves using hand instruments to access carious lesions through enamel and to remove a selected amount of demineralised dental tissues. **This is sometimes known as a minimally invasive treatment.**

How it works and clinical effectiveness

ART restorations with HVGIC have shown high success in long-term follow up studies for single surfaces, in the primary and permanent dentitions with meta-analyses showing weighted mean annual failure percentages in primary molars over the first three years of 5% and 4.1% over the first five years in permanent posterior teeth.[29] However, there are not enough

studies on multi-surface restorations in the permanent dentition to recommend it as a long-term strategy yet. A recent systematic review reported no significant differences in survival percentages between ART and traditionally produced multiple-surface restorations in primary molars[72] and for single-surface restorations in primary molars and posterior permanent teeth.[73] Large sized multi-surface ART/HVGIC restorations in primary molars were less successful because of poor restorative material performance rather than the caries removal technique. However, ART may be a good short-term strategy for large multi-surface cavities or for stabilising the dentitions prior to other restorative interventions.

Non-AGP use

ART involves no rotary, aerosol producing, instruments during opening of the cavity and selective removal of the carious tissue. ART's success is determined by not only the shape and the sharpness of the hand instruments, but also the technique used and knowledge of the affected dental tissues and experience of the dental practitioner.

In some deeper lesions in permanent teeth, stepwise carious tissue removal may have been the treatment of choice but involves a second high-speed air rotor step to remove the restoration. **Therefore, following selective carious tissue removal, a restoration designed to last for the long-term should be placed. The restoration seal should be checked and maintained as necessary on a regular basis.**

Chemo-mechanical methods for carious tissue removal

Currently, there are sodium hypochlorite based and enzyme-based chemo-mechanical caries removal agents in the market. A recent systematic review found chemo-mechanical caries removal time consuming, but effective, for caries removal.[74] The manufacturer' recommendations are that the caries removal agents are washed out but could well be removed with spoon instruments and cleaned with wet cotton pellets.

Limitations of non-AGP and low AGP in management of carious lesions

The majority of carious lesions in children and young adults can be treated with non-AGP measures because they are usually the first lesion on a tooth. One of the difficulties with applying non-AGPs in adults is that most lesions occur in relation to a failing restoration (previously known as secondary caries) and it does not seem possible to remove restorative

materials without using rotary instruments and creating aerosols. However, repairing existing restorations rather than replacing them should be considered where possible.

Conclusion

Treatments that remove or reduce the generation of aerosols during the management of carious lesions can allow a successful risk reduction approach.

Declaration of interests

None

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Lesion location	High AGP*	Low-AGP*	Non-AGP
Carious lesions limited to enamel			
Smooth surface	Not applicable	Resin infiltration	• 1. Maximise fluoride during toothbrushing • 2. Topical fluoride therapy • (3. Other remineralisation agents**)
Occlusal surface	Not applicable	Resin fissure sealant	• ART/HVGIC sealant • GIC sealant
Aproximal surface	Not applicable	Resin infiltration	• Fluoride • (Other remineralisation agents**)
Carious lesion extending into dentine or on root surface			
Smooth or root surface	Carious tissue removal (high speed air rotor) & composite resin restoration	Not applicable	• ART restoration • NRCC • SDF
Occlusal surface	Carious tissue removal with (high speed air rotor) & composite resin restoration	Resin fissure sealant (minimal enamel breakdown)	• ART restoration • NRCC*** • SDF
Aproximal / multi-surface	1. Carious tissue removal (high speed air rotor) & composite resin restoration 2. Stainless steel crown (conventional placement) 3. Zirconia crown	Resin infiltration (outer 1/3 dentine)	• ART restoration *** • Hall Technique • NRCC*** • SDF ***

* Use rubber dam with sealant around tooth/dam interface and high-volume aspiration
** CPP-ACP could be used as an additional measure but should not replace fluoride. Peptides some, though limited evidence to support them. SDF is not recommended for anterior teeth unless the discolouration is acceptable (e.g. might be useful in anterior primary teeth)
*** only for primary teeth
ART – Atraumatic Restorative Treatment
CMCR – Chemo-mechanical Caries Removal
GIC – Glass ionomer cement
HVGIC - High-viscosity glass- ionomer cement fissure Sealant
NRCC – Non-restorative Cavity Control
SDF – Silver Diamine Fluoride

Figure 1 Direct restorative procedures (i.e. not involving a laboratory stage) for managing coronal and root surface carious lesions for permanent and primary teeth with high, low and non-aerosol generating procedure alternatives.

Depth of Carious Lesion	Occlusal		Multi-surface	
	Primary teeth	Permanent teeth	Primary teeth	Permanent teeth
Limited to enamel	• APP • TF • SDF	• APP • TF • ART/HVGIC FS	• APP • TF • SDF • RI	• APP • TF • RI
Extending no more than the outer ⅓ to ½ of dentine	• NRCC • SDF • ART +/-CMCR	• ART* (+/- CMCR)	• NRCC • SDF • ART +/-CMCR • HT	• ART* +/-CMCR
Over ½ way through dentine	• ART** +/- CMCR +/- SDF	• ART** +/- CMCR +/- SDF	• ART** +/- CMCR • HT +/-SDF	• ART** +/- CMCR +/- SDF

APP – Active Primary Prevention
ART – Atraumatic Restorative Treatment
ART/HVGIC FS – Atraumatic Restorative Treatment Fissure Sealant using high-viscosity glass-ionomer cement
CMCR – Chemo-Mechanical Caries Removal
HT – Hall Technique
NRCC – Non-restorative Cavity Control
RI – Resin infiltration
SDF – Silver Diamine Fluoride
TF – Topical Fluoride

* Because the lesion is shallow, it is likely that complete carious tissue removal will be necessary to give adequate depth to the restorative material
** Because the lesion is deeper selective carious tissue removal can be carried out

Figure 2. Non-aerosol caries management options

Figure 3. Further resources*

General

There are some video tutorials of techniques available through the University of Dundee, School of Dentistry covering; "how to" for Selective Caries Removal, ART, the Hall Technique and techniques for placing glass ionomer fissure sealants.
https://www.youtube.com/c/DundeeDentalSchool/videos

For permanent and primary teeth in children, indications/ contra-indications and more information can also be found in the full guidance version of the Scottish Dental Clinical Effectiveness guideline https://www.sdcep.org.uk/published-guidance/caries-in-children/. Section 10 also provides a guide on how to carry out most of the procedures covered here.

Silver Diamine Fluoride

Wikipedia* https://en.wikipedia.org/wiki/Silver_diammine_fluoride
A guide to the use of SDF can be found in this British Dental Journal article
https://www.nature.com/articles/s41415-020-1203-9
ADA video on placement of SDF https://youtu.be/a0HH7GifdM4
US IHS video on placement of SDF https://youtu.be/aTDFAYxBbus
A video on the use of the SDF in children https://youtu.be/7aiyiRnXhQE
Resources with patient information leaflets and Standard Operating Procedures can be found on the British Society for Paediatric Dentistry website
https://www.bspd.co.uk/Professionals/Resources

Hall Technique

A video showing use of the Hall Technique in children https://youtu.be/ndxQEDw0rAM
Wikipedia guide with an pdf of a manual on how to carry out the technique:
https://en.wikipedia.org/wiki/Hall_Technique

Atraumatic Restorative Treatment

Wikipedia* https://en.wikipedia.org/wiki/Atraumatic_Restorative_Treatment_(ART)

***** Although not always the most reliable source of information, with the support of Cochrane and the Wikipedia Editing Collaboration of Dental Schools, much of the information on Wikipedia related to Dentistry is being updated and the pages for ART and SDF have recently been added and contain useful links. Please note that these are open for all to edit so are subject to non-peer reviewed changes.